



DECLARATION FOR TRANSLATION

I, Jun Ishida, a Patent Attorney, of 1-34-12, Kichijoji-Honcho, Musashino-shi, Tokyo, Japan, do solemnly and sincerely declare that I well understand the Japanese and English languages and that the attached English version is a full, true and faithful translation made by me

this 9th day of August 2002

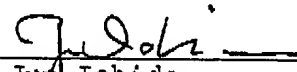
of the Japanese priority document of

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No. Hei 11-12280

entitled "ELECTROLUMINESCENCE DISPLAY DEVICE".

In testimony thereof, I herein set my name and seal

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[Title of the Invention] ELECTROLUMINESCENCE DISPLAY DEVICE

[Claims]

1. An electroluminescence display device, comprising:

5 an electroluminescence element having a light-emitting layer
between an anode and a cathode;

 a first thin film transistor, wherein a source in an active layer
made of non-monocrystalline semiconductor film is connected to an
auxiliary capacitor, a drain in the active layer is connected to a
10 drain signal line, and a gate electrode provided above a channel in
the active layer is connected to a gate signal line, respectively;
and

 a second thin film transistor, wherein a drain in an active layer
made of non-monocrystalline semiconductor film is connected to a driving
15 power supply for the electroluminescence element, and a gate is connected
to the source of the first thin film transistor, respectively, wherein:

 the first thin film transistor includes an n-type channel and
has any one structure from among an LDD structure, a multi-gate structure,
and an offset structure; and

20 the second thin film transistor includes a p-type channel.

2. An electroluminescence display device, comprising:

 an electroluminescence element having a light-emitting layer
between an anode and a cathode;

25 a first thin film transistor, wherein a source in an active layer
made of non-monocrystalline semiconductor film is connected to an

auxiliary capacitor, a drain in the active layer is connected to a drain signal line, and a gate electrode provided below a channel in the active layer is connected to a gate signal line, respectively; and

5 a second thin film transistor, wherein a drain in an active layer made of non-monocrystalline semiconductor film is connected to a driving power supply for the electroluminescence element, and a gate is connected to the source of the first thin film transistor, respectively, wherein:

the first thin film transistor includes an n-type channel and
10 has any one structure from among an LDD structure, a multi-gate structure, and an offset structure; and

the second thin film transistor includes a p-type channel.

[Detailed Explanation of the Invention]

15 [0001]

[Field of the Invention]

The present invention relates to an electroluminescence display device provided with an electroluminescence element and a thin film transistor.

20 [0002]

[Description of the Prior Art]

In recent years, electroluminescence (Electro Luminescence: hereinafter referred to as "EL") display devices using EL elements have received attention as alternative display devices to CRTs and
25 LCDs. For example, an EL display device including a thin film transistor (Thin Film Transistor: hereinafter referred to as "TFT") used as a

switching element for driving the EL element has been researched and developed.

[0003]

In Fig. 6, an equivalent circuit diagram of a conventional EL display device including an EL element and TFTs is shown.

[0004]

This diagram is an equivalent circuit diagram of an EL display device including a first TFT 130, a second TFT 140, and an organic EL element 160, and illustrates a portion near a gate signal line G_n in the n^{th} row and a drain signal line D_m in the m^{th} column.

[0005]

The gate signal line G_n for supplying a gate signal and the drain signal line D_m for supplying a drain signal intersect perpendicular to each other, and, in the vicinity of the intersection of both signal lines, the organic EL element 160 and the TFTs 130 and 140 for driving the organic EL element 160 are provided.

[0006]

The first TFT 130 as a switching TFT includes a gate electrode 131 connected to the gate signal line G_n and supplied with the gate signal, a drain electrode 132 connected to the drain signal line D_m and supplied with the drain signal, and a source electrode 133 connected to a gate electrode 141 of the second TFT 140.

[0007]

The second TFT 140 as a TFT for driving the organic EL element includes the gate electrode 141 connected to the source electrode 133 of the first TFT 130, a source electrode 142 connected to an anode

161 of the organic EL element 160, and a drain electrode 143 connected to a driving power supply 150 from which the organic EL element 160 is powered.

[0008]

5 The organic EL element 160 includes the anode 161 connected to the source electrode 142, a cathode 162 connected to a common electrode 164, and a light-emitting element layer 163 sandwiched between the anode 161 and the cathode 162.

[0009]

10 The device further includes an auxiliary capacitor 170 wherein one electrode 171 is connected between the source electrode 133 of the first TFT 130 and the gate electrode 141 of the second TFT 140, and the other electrode 172 is connected to a common electrode 173.

[0010]

15 A method for driving the circuit shown in the equivalent circuit diagram of Fig. 6 will be described hereinafter with reference to respective signal timing charts shown in Fig. 7. Fig. 7(a) shows a timing chart of a signal VG(n)1 to be supplied to the gate electrode 131 of the first TFT 130 in the nth row, Fig. 7(b) shows that of a drain signal VD of the drain signal line Dn, and Fig. 7(c) shows that of a signal VG(n)2 to be supplied to the gate electrode 141 of the second TFT 140 in the nth row, respectively.

[0011]

25 When the gate signal VG(n)1 shown in Fig. 7(a) is applied from the gate signal line Gn to the gate electrode 131, the first TFT 130 is switched on. As a result, the drain signal VD shown in Fig. 7(b)

is supplied from the drain signal line Dm to the gate electrode 141, so that the gate electrode 141 becomes at the same potential as the drain signal line Dm. A current corresponding to the amperage of current supplied to the gate electrode 141 is then supplied from the driving
5 power supply 150 to the organic EL element 160. Thus, the organic EL element 160 emits light.

[0012]

[Problems to be solved by the Invention]

While the first TFT 130 stays on, a current flows until the
10 potential of the gate electrode 141 becomes the same as that of the drain signal line Dm, and electric charges are stored in a gate capacitor of the gate electrode 141. After the first TFT 130 is switched off, the electric charges stored in the gate capacitor must remain in that state, and the gate potential must be retained as indicated by a broken
15 line in Fig. 7(c).

[0013]

However, in the above-described conventional EL display device, a leakage current flows while the TFT is off. As a result, when the drain signal VD changes every horizontal period (1H) as shown in Fig.
20 6(b), the potential VG(n)2 of the gate electrode 141 changes as indicated by a solid line in Fig. 6(c) and cannot be retained.

[0014]

More specifically, as indicated by the solid line in Fig. 7(c),
(1) when the potential of the drain signal line Dm is lower than that
25 supplied to the gate electrode 141, a leakage current flows to the drain signal line Dm through the first TFT 130, and the potential of

the gate electrode 141 is decreased, and (2) when the potential of the drain signal line Dm is higher than that supplied to the gate electrode 141, a leakage current flows to the gate electrode 141 through the first TFT 130, and electric charges are further stored and the potential
5 of the gate electrode 141 is increased.

[0015]

Thus, in the case (1), a larger current than that essential to be fed through the organic EL element 160 flows, thereby increasing the brightness of the organic EL element. On the other hand, in the
10 case (2), the brightness is reduced.

[0016]

In either case, as indicated by the broken line in Fig. 7(c), when a leakage current through the first TFT 130 is large, there is a drawback in that it is difficult for the light-emitting display pixels
15 to emit light of an appropriate brightness.

[0017]

The second TFT has the function of controlling the current from the power supply for driving the organic EL according to the voltage applied to the gate of the second TFT and supplying the current to
20 the organic EL element. An active layer of the second TFT has, in a channel region superposing on the gate, an intrinsic or substantially intrinsic region, and, on both sides thereof, source and drain regions doped with an impurity.

[0018]

25 However, as indicated by a broken line in Fig. 9, when the second TFT is an n-channel transistor, in the drain current-drain voltage

(I_d - V_d) characteristics, a region where the drain current amperage I_d is constant even when the drain voltage V_d is increased, i.e. a so-called saturation region is extremely narrow (saturation characteristics are poor). Consequently, the current amperage I_d is increased as the V_d value is increased, and therefore a constant current cannot be obtained depending on the voltage V_d , leading to a drawback of poor current controllability.

[0019]

Especially, in an n-channel polycrystalline silicon TFT, with grain boundaries of crystals existing, electrons trapped in the grain boundaries form a potential barrier and a depletion layer spreads. As a result, a strong electric field is applied to the grain boundaries at the edges of the drain electrode, causing an occurrence of a collision-ionization phenomenon in which accelerated electrons collide with lattices, and therefore the drain current does not reach saturation and increases.

[0020]

Thus, the present invention is made in light of the above drawbacks in the prior art. An object of the present invention is to provide an EL display device wherein a leakage current through the first TFT 130 is suppressed to retain the potential of the gate electrode 141 in the second TFT 140 and to improve the current controllability of the second TFT 140 and to thereby acquire an excellent gradation display.

[0021]

[Means for solving the Problems]

An EL display device according to the present invention comprises

an electroluminescence element having a light-emitting layer between an anode and a cathode; a first thin film transistor, wherein a source in an active layer made of non-monocrystalline semiconductor film is connected to an auxiliary capacitor, a drain in the active layer is connected to a drain signal line, and a gate electrode provided above a channel in the active layer is connected to a gate signal line, respectively; and a second thin film transistor, wherein a drain in the active layer made of non-monocrystalline semiconductor film is connected to a driving power supply for the electroluminescence element, and a gate is connected to the source in the first thin film transistor, respectively. The first thin film transistor includes an n-type channel and has any one structure from among an LDD structure, a multi-gate structure, and an offset structure. The second thin film transistor includes a p-type channel.

[0022]

Furthermore, an EL display device according to the present invention comprises an electroluminescence element having a light-emitting layer between an anode and a cathode; a first thin film transistor, wherein a source in an active layer made of non-monocrystalline semiconductor film is connected to an auxiliary capacitor, a drain in the active layer is connected to a drain signal line, and a gate electrode provided below a channel in the active layer is connected to a gate signal line, respectively; and a second thin film transistor, wherein a drain in the active layer made of non-monocrystalline semiconductor film is connected to a driving power supply for the electroluminescence element, and a gate is connected

to the source in the first thin film transistor, respectively. The first thin film transistor includes an n-type channel and has any one structure from among an LDD structure, a multi-gate structure, and an offset structure. The second thin film transistor includes a p-type channel.

[0023]

[Preferred Embodiments]

An EL display device of the present invention will be described hereinafter.

10 <First Embodiment>

Fig. 1 shows a plan view showing a single display pixel when the present invention is applied to an organic EL display device. Fig. 2(a) shows a cross-sectional view taken along a line A-A in Fig. 1, and Fig. 2(b) shows a cross-sectional view taken along a line B-B in Fig. 1.

[0024]

As shown in Fig. 1, a display pixel is formed in a region surrounded by gate signal lines 51 and drain signal lines 52. A first TFT 30 is provided near an intersection point of both signal lines. A source 13s of the TFT 30 also serves as a capacitor electrode 55 for constituting an auxiliary capacitor between the capacitor electrode 55 and an auxiliary capacitor electrode line 54 to be described later, and is connected to a gate 41 of a second TFT 40. A source 43s of the second TFT 40 is connected to an anode 61 of an organic EL, and a drain 43d on the other side is connected to a driving power supply line 53 for driving an organic EL element.

044000000 (A) 110000 7000 000000 000000

[0025]

Furthermore, the auxiliary capacitor electrode line 54 is disposed near the TFTs in parallel to the gate signal lines 51. This auxiliary capacitor electrode line 54 is formed of chromium or the like, and constitutes the auxiliary capacitor by storing electric charges between the line 54 and the capacitor electrode 55 connected to the source 13s of the TFT with a gate insulating film 12 in between. The auxiliary capacitor is provided for retaining the voltage to be applied to the gate electrode 41 of the second TFT 40.

[0026]

As shown in Fig. 2, the organic EL display device is formed by laminating TFTs and organic EL elements in this order on a substrate 10 such as a substrate formed of glass, synthetic resin, or the like; a conductive substrate; and a semiconductor substrate. It should be noted that, when a conductive substrate or a semiconductor substrate is used as the substrate 10, the TFTs and the organic EL display device are formed after forming an insulating film of SiO_2 , SiN , or the like on the substrate 10.

[0027]

In the present embodiment, shown is a case where both the first and second TFTs 30 and 40 are so-called bottom-gate-type TFTs each with a gate electrode provided below an active layer 13, and polycrystalline silicon (Poly-Silicon; hereinafter referred to as "p-Si") film is used as the active layer. Shown is also a case of the TFT in which the gate electrode 11 has a double-gate structure.

[0028]

[0029]

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[0031]

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[0033]

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[0034]

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[0035]

p-Si film are formed in this order.

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channel 43c is provided above the gate electrode 41, and, on both sides

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On the entire surface over the gate insulating film 12 and the

active layer 43, the interlayer insulating film 15 wherein an SiO₂ film, an SiN film, and an SiO₂ film are laminated in this order is next formed, and the driving power supply line 53 connected to a driving power supply 50 is formed by filling metal such as Al in a contact hole provided
5 corresponding to the drain 43d. Further, the planarization insulating film 17, which is made of, for example, organic resin and is for planarizing the surface, is formed on the entire surface. A contact hole is formed in the planarization insulating film 17 at a position corresponding to the source 43s, and then a transparent electrode,
10 i.e. the anode 61 of the organic EL element, which is made of ITO and in contact with the source 13s through the contact hole, is formed on the planarization insulating film 17.

[0038]

The organic EL element 60, having a general structure, is
15 lamination of the anode 61 made of a transparent electrode of ITO (Indium Thin Oxide) or the like, a light-emitting element layer 65 consisting of a first hole-transport layer 62 made of MTDATA (4, 4-bis(3-methylphenylphenylamino)biphenyl), a second hole-transport layer 63 made of TPD (4, 4, 4-tris(3-methylphenylphenylamino)triphenylamine), a
20 light-emitting layer 64 made of Beq2 (10-benzo[h]quinolinol-beryllium complex) including Quinacridone derivatives, and an electron-transport layer made of Beq2, and a cathode 66 made of magnesium-indium alloy, in this order.

[0039]

25 In the organic EL element, holes injected from the anode and electrons injected from the cathode recombine inside the light-emitting

layer to excite organic molecules forming the light-emitting layer, thereby producing excitons. Light is released from the light-emitting layer during the process in which the excitons deactivate, and this light is released from the transparent anode through the transparent insulating substrate to the outside, resulting in light emission.

[0040]

In Fig. 3, timing charts of individual signals are shown. It should be noted that the equivalent circuit of the organic EL display device according to the present embodiment is the same as that in the above-described Fig. 6.

[0041]

In Fig. 3, charts (a), (b), and (c) show timing charts of a signal VG(n)1 to be supplied to the gate electrode in the first TFT in the n^{th} row, a drain signal VD in the m^{th} column, and a signal VG(n)2 to the gate electrode in the second TFT in the n^{th} row, respectively.

[0042]

As shown in Fig. 3(a), when the gate signal is supplied to the gate 11 connected to the gate signal line Gn, the first TFT 30 remains in an ON state for a single horizontal period (1H) prior to being switched off. In such an ON state, as shown in Fig. 3(c), the drain signal shown in Fig. 3(b) is supplied from the drain signal line Dm through the source 43s to the gate electrode 41, thereby causing the gate electrode 41 to be at the same potential as the drain signal line Dm. When a potential is supplied to the gate electrode 41 in such a manner, the second TFT 40 is switched on, and a current corresponding to the amperage of the gate electrode 41 is supplied from the driving power supply

50 through the drain 43d and the source 43s to the anode 61 in the organic EL element 60. Thus, the organic EL element 60 emits light.

[0043]

The display pixels in such a configuration are arranged in a matrix on the substrate 10, thereby constituting the organic EL display device.

[0044]

As described above, according to the present invention, the first TFT 30 is an n-channel TFT with an LDD structure including the active layer 13 with the source and drain doped with an n-type impurity, and therefore electric-field mobility is high and a leakage current of the first TFT 30 can be suppressed. In other words, a write operation can be performed at high speed and voltage-retaining characteristics are excellent. Because of this, the drain signal can be written following the signal that changes every 1H as shown in Fig. 3(b). The potential of the gate electrode 41, not changing as in the conventional case indicated by a broken line in Fig. 3(c), can be retained as indicated by a solid line. In addition, a high ON current can be obtained as indicated by a solid line in Fig. 8. Accordingly, a current for light emission can be stably supplied to the organic EL element without any reduction.

[0045]

Furthermore, as the second TFT 40 is a p-channel TFT having the active layer with the source and drain doped with a p-type impurity, a saturation region in the I_d - V_d characteristics can be extended as indicated by a solid line in Fig. 9, and I_d therefore becomes hard

to change according to V_d . In other words, variation in the amperage of the drain current according to a change in the drain voltage is reduced. Accordingly, the light-emission brightness of the organic EL element can be made uniform with excellent reproducibility, and
5 therefore an excellent gradation display can be easily acquired.

[0046]

As described above in the section on the prior art, the grain boundaries of crystals are present especially in the polycrystalline silicon TFT, the electrons trapped in the grain boundaries form a
10 potential barrier, and a depletion layer spreads. As a result, a strong electric field is applied to the grain boundaries at the edges of the drain electrode, thereby generating a collision ionization phenomenon where the accelerated electrons collide with lattices. Upon comparison with the case of an n-channel TFT, the phenomenon is significantly
15 smaller in the p-channel case, and therefore the drain current can attain excellent saturation characteristics showing a saturation region. Accordingly, a p-channel TFT is used for the second TFT.

[0047]

As described above, with the first TFT having an n-type channel
20 with an LDD structure and the second TFT having a p-type channel, an organic EL display device is thereby obtained wherein a high-speed write operation can be performed, a leakage current can be suppressed, and a light-emission brightness with excellent reproducibility can be obtained.

25 <Second Embodiment>

In Fig. 4, shown is a cross-sectional view of a first TFT in

an EL display device according to the present invention.

[0048]

The present embodiment differs from the first embodiment in that the first TFT is n-channel with a double-gate structure and an offset structure as shown in Fig. 4.

[0049]

As shown in Fig. 4, in the first TFT, within an active layer of p-Si that is provided on a lamination of a gate electrode 11 and a gate insulating film 12, intrinsic or substantially intrinsic regions 130s are formed over the gate electrode 11 on both sides of the gate electrode 11. These regions are so-called offset regions. Further, regions indicated by slanting lines in the figure are a source 13s and a drain 13d that are doped with an n-type impurity such as phosphorus or the like. Thus, the first TFT has a so-called offset structure including such offset regions.

[0050]

As described above, as the first TFT with an n-type channel has a double-gate structure and an offset structure, an electric-field mobility can be increased and a leakage current can be reduced. Further, as a TFT with a p-type channel is used as a second TFT as in the first embodiment, an organic EL display device is obtained wherein variation in a drain current can be reduced with respect to a drain voltage, light-emission brightness of organic EL elements can be made uniform with excellent reproducibility, and excellent gradation display can be obtained.

<Third Embodiment>

In the present embodiment, described is a case where a so-called top-gate-type TFT with a gate electrode provided above an active layer 13 is used for each of first and second TFTs 30 and 40. Further, the TFT wherein the gate electrodes 11 form a double-gate structure is described.

[0051]

A cross-sectional view of the first TFT is shown in Fig. 5(a), and a cross-sectional view of the second TFT is shown in Fig. 5(b).

[0052]

As shown in Fig. 5(a), the active layer of p-Si is formed on an insulating substrate 10. In the active layer 13, channels 13c are formed which overlap the two gate electrodes 11 formed with a gate insulating film 12 in between, and, on both sides of the channels 13c, low concentration regions 13LD doped with an n-type low-concentration impurity such as phosphorus or the like are formed. Further, high concentration regions doped with an n-type impurity are formed as a source 13s and a drain 13d.

[0053]

Thus, the first switching TFT having an LDD structure and a top-gate structure is formed.

[0054]

As shown in Fig. 5(b), an active layer 43 is formed on the insulating substrate 10 concurrently with the formation of the active layer 13 in the first TFT. In the active layer 43, as in the first TFT, a channel 43c is formed which overlaps the two gate electrodes 41 formed with the gate insulating film 12 in between, and a source 43s and a drain

43d are formed by doping regions on both sides of the channel 43c with a p-type impurity such as boron (B) or the like. The source 43s is connected to an anode 61 of an organic EL element. Note that, because the structure of the organic EL element is similar to that in the first embodiment, the explanation thereof will be omitted.

[0055]

Thus, the second organic-EL-element-driving TFT with a p-type channel is formed.

[0056]

As for a case where the first and second TFTs have top-gate structures as described above, similar to the above-noted case where the bottom-gate structure is provided, a first TFT can be obtained wherein a write operation can be performed at high speed because of high electric-field mobility and voltage-retaining characteristics are excellent because of small leakage current, and a second TFT can be obtained wherein saturation characteristics are excellent and variation in current amperage is small.

[0057]

As a result, an organic EL display device that is excellent in video-signal-retaining characteristics and capable of satisfactory gradation display can be obtained.

[0058]

Furthermore, while the first TFT is described as having a double-gate structure in each of the above embodiments, the present invention is not limited thereto, and can be applied to a multi-gate structure having three or more gate electrodes.

[0059]

Likewise, while a p-Si film is used as the active layer in each of the above embodiments, a microcrystalline silicon film or amorphous silicon can be also used.

5 [0060]

Additionally, while an organic EL display device is described in each of the above embodiments, the present invention is not limited thereto, and can be also applied to an inorganic EL display device wherein a light-emitting layer is made of an inorganic material, with
10 similar advantages.

[0061]

[Advantages]

The EL display device according to the present invention is provided with a first TFT wherein a write operation is performed at
15 high speed and retaining characteristics are excellent and a second TFT wherein current controllability is excellent, so that the EL display device capable of satisfactory gradation display can be obtained.

[Brief Description of the Drawings]

[Fig. 1]

20 A plan view showing an EL display device of the present invention.

[Fig. 2]

Cross-sectional views showing the EL display device of the present invention.

[Fig. 3]

25 Timing charts showing individual signals in the EL display device of the present invention.

[Fig. 4]

A cross-sectional view showing the EL display device of the present invention.

[Fig. 5]

5 Cross-sectional views showing the EL display device of the present invention.

[Fig. 6]

An equivalent circuit diagram showing an EL display device.

[Fig. 7]

10 Timing charts showing individual signals in a conventional EL display device.

[Fig. 8]

A plot showing characteristics of a TFT.

[Fig. 9]

15 A plot showing characteristics of a TFT.

[Explanation of Reference Numerals]

11, 41	GATE
13s, 43s	SOURCE
13d, 43d	DRAIN
20 13c, 43c	CHANNEL
13s, 43s	LDD REGION
30	FIRST TFT
40	SECOND TFT
50	DRIVING POWER SUPPLY
25 60	ORGANIC EL ELEMENT

[Name of Document] Abstract of the Disclosure

[Summary]

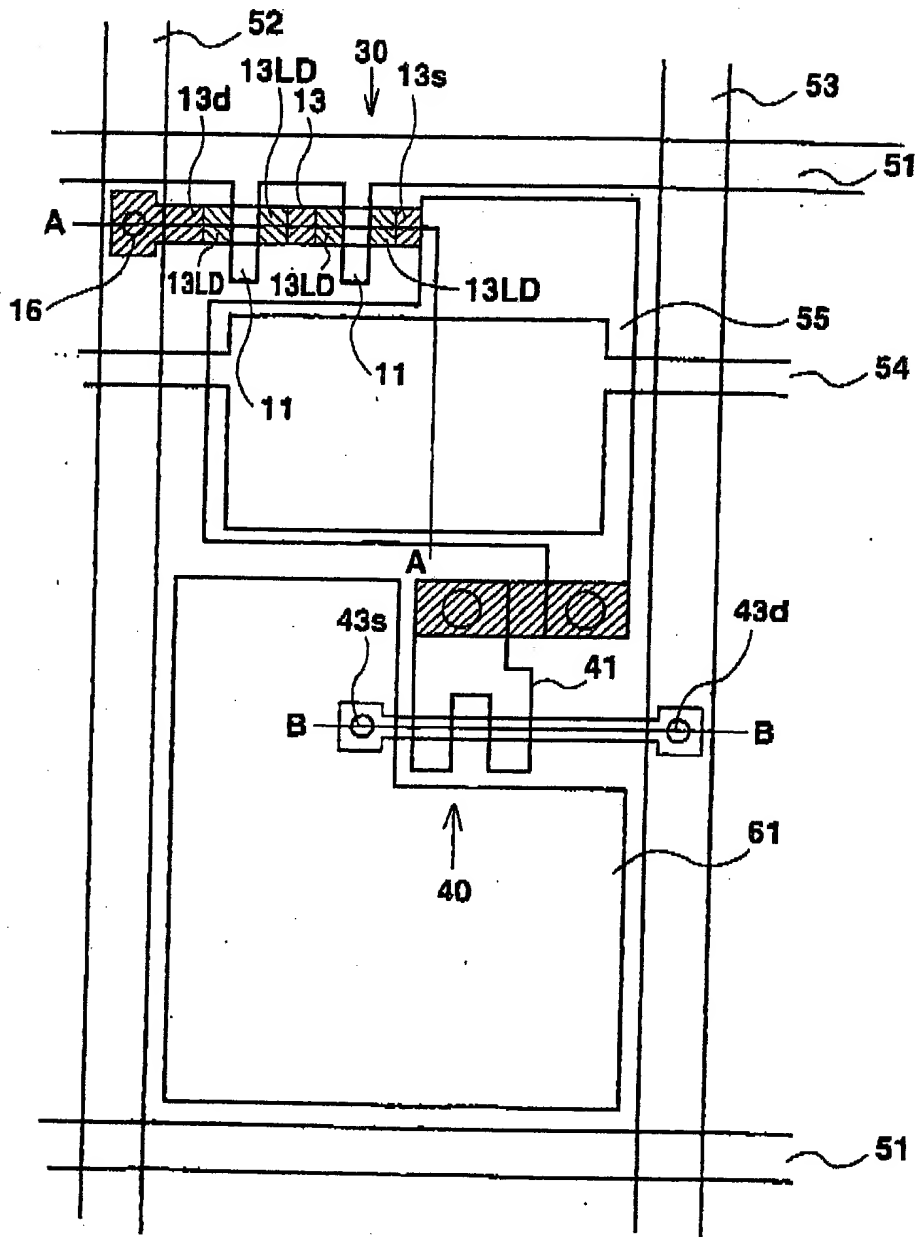
[Problems] To provide an EL display device capable of satisfactory gradation display owing to a first TFT with a high-speed write operation and excellent retaining characteristics and a second TFT with excellent current controllability.

[Structure] In an organic EL display device including a first switching TFT 30, a second TFT for driving an organic EL element, and an organic EL element 60 consisting of an anode 61, a cathode 66, and a light-emitting element layer 65 sandwiched between these two electrodes, the first TFT 30 has an n-type channel and an LDD structure, and the second TFT has a structure having a p-type channel. Consequently, an ON current can be increased, a leakage current can be decreased, and a satisfactory gradation display can be obtained.

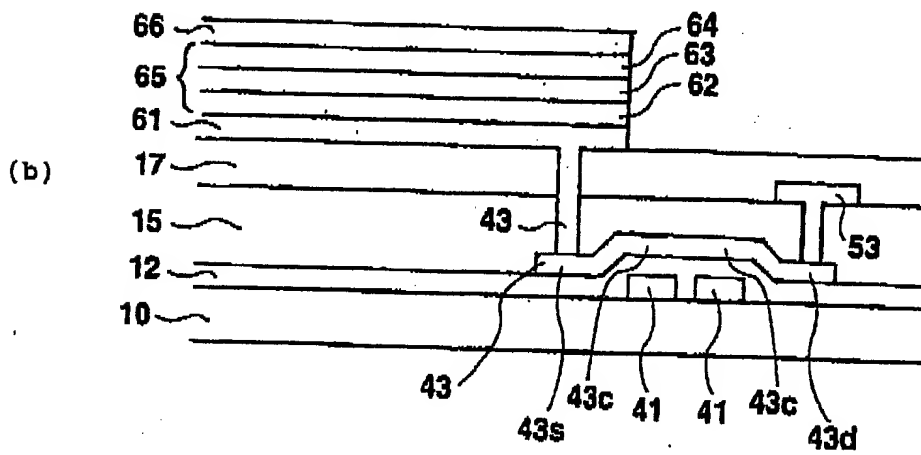
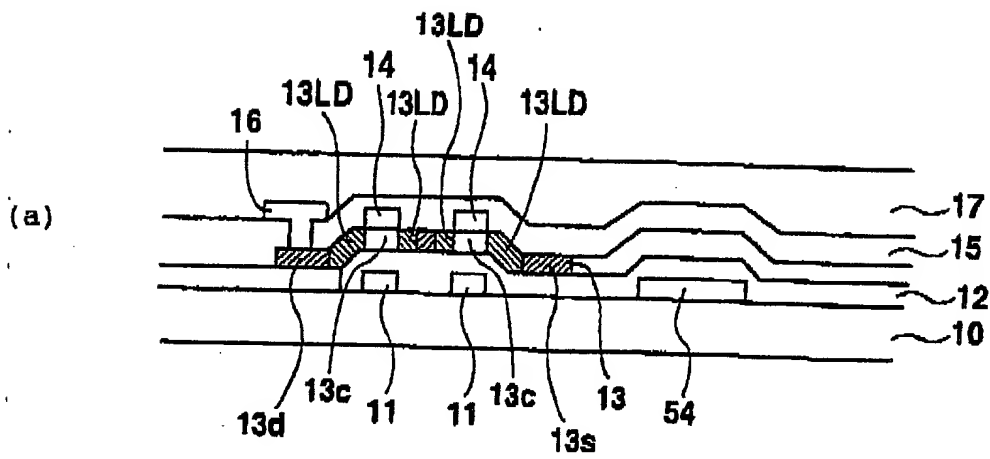
[Selected Drawing] Fig. 1

Drawings

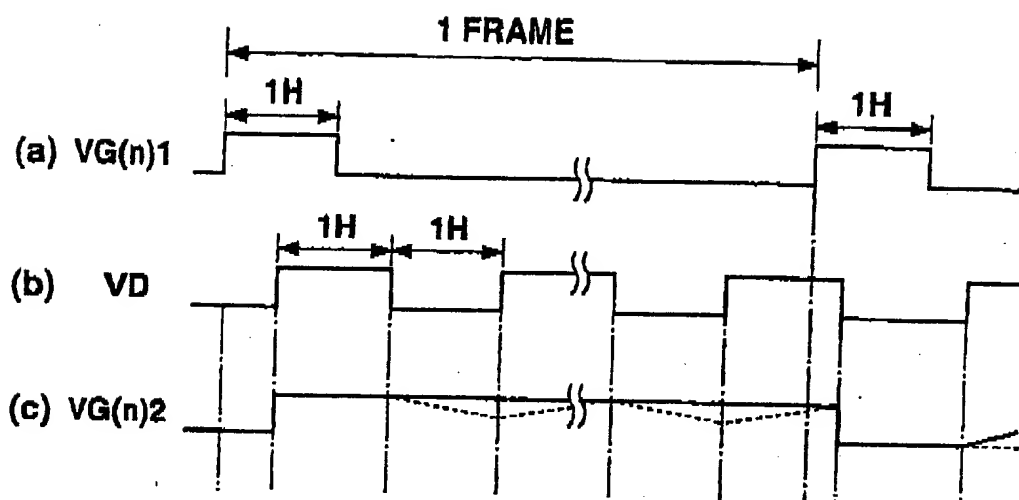
[Fig. 1]



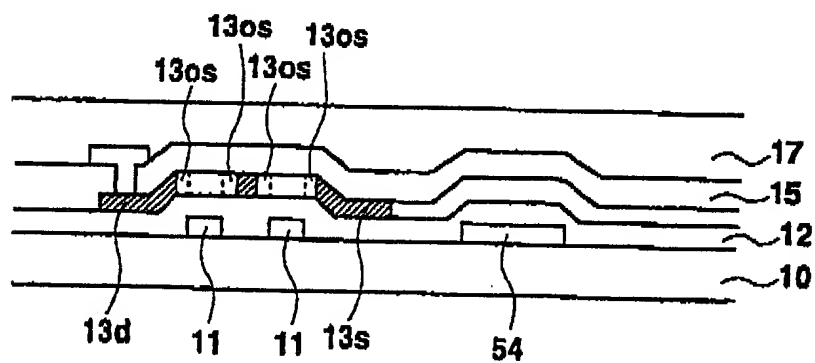
[Fig. 2]



[Fig. 3]



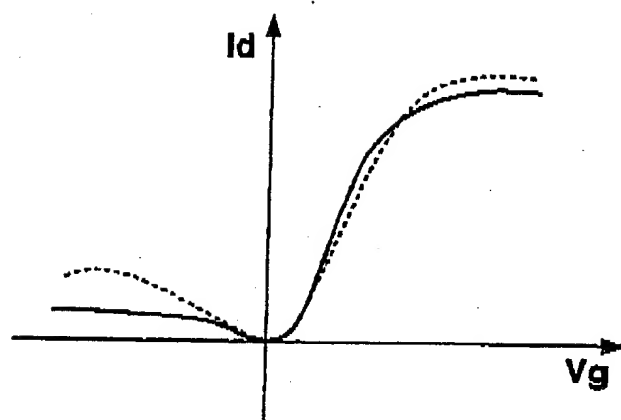
[Fig. 4]



[Fig. 5]



[Fig. 8]



[Fig. 9]

